

flower shows that all parts have changed, and are decidedly leaf-like, though not to the same extent. Of the sepals (Fig. 2.) two are larger than the others, are very distinctly veined, and have a few small teeth near their tips; the remaining sepals are narrow, elongated, and have only the midrib without any lateral veins. The petals have lost their papilionaceous character entirely, though the vexillum may be recognized by its larger size. Each petal (Figs. 3, 4.) is leaf-like in shape, veining, and especially in the possession of a pair of stipules which are fused with its base precisely, as are the stipules of the leaf proper. The petals project but slightly from the tube of the calyx.



Fig. 3.



Fig. 4.

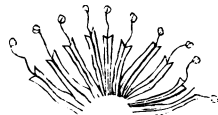


Fig. 5.

The stamens (Fig. 5.) are not diminished in number, but are separate, and each filament bears the stipules distinctly. They are joined with it nearly to the anther. This would seem to indicate that the sheath of united stamens in the *Leguminosæ* is made by the fusion of the stipular elements of the leaf alone.

Within the stamens, and occupying the centre of the flower, is a single, rather long-stemmed leaflet, apparently the middle one of the three so characteristic of the trifoliums. It is unmistakably a leaf in its veining, outline, color, etc., and upon its petiolar portions are borne—as might be expected—the stipules; in this case as plainly stipules as those which are borne by the true foliage leaves. No trace of a pistilline nature is to be seen. The reversion has been complete. All the parts, except the stamens are exceedingly hairy.

The peculiar feature in this case is the retention of the stipules as separate parts in all the whorls, excepting the calyx, where they are undistinguishably fused to form the cup-like portion of that organ.

The ease with which these reverted flowers can be obtained and studied, and the light which they throw upon the morphology of the parts of the flower make them worthy the attention of students who ought, as soon as possible, to gain a practical knowledge of the real nature of floral parts.

A demonstration in mathematics could not be more conclusive than this lesson from *Trifolium pratense*, our familiar red clover.

Pennsylvania State College, Dec. 20, 1880.

THE CLASSIFICATION OF SCIENCE.

By REV. SAMUEL FLEMING, LL. D., Ph. D.

I.

DEFINITIONS.

The term science has been variously defined. It is from the Latin *scientia* (from *scio*, I know,) which is defined as “a knowing, or being skilled in anything; generally, knowledge, science.” The original sense of

the term *scientia* involves the twofold conception, of the *thing*, or fact itself, which is the subject of knowledge, and the *knowing* the fact. The former is the *objective* signification, the latter the *subjective*. In defining the term, therefore, diverse forms of expression have been used, and different senses conveyed. In the edition of Webster's Unabridged Dictionary, published in 1878, modified definitions are given as follows: “Knowledge; the comprehension of truth or fact; truth ascertained; that which is known; hence, specifically, knowledge duly arranged, and referred to general truths on which it is founded.” By some, the definition given is “systematic knowledge”; by others, “what is comprehended by the mind”; another definition is in the following language: “Science is the name for such portions of human knowledge as have been more or less generalized, systematized and verified.” Herbert Spencer gives the following, corresponding with the general divisions of his “Classification of the Sciences”: 1. That which treats of the forms in which phenomena are known to us; 2. That which treats of the phenomena themselves. Prof. Tice, after stating that “there is a broad distinction between knowledge and science,” gives this distinction in the following terms: “Knowledge is a clear and certain perception of that which exists, or of truth or of fact. Science is a body of general principles: particular truths, and facts, arranged in systematic order.”

The terms science and knowledge have sometimes been used as synonymous; frequently without due discrimination. It is evident that the facts of science, if not science itself, exist prior to, or irrespective of the mind which acquires the knowledge of them, if we except the science of the mind itself. Existence is one thing, the knowledge of such existence is radically another thing. Hence the propriety, and often great importance of recognizing this distinction, and of discriminating in the use of the terms. Scientific terms should be used with definiteness of meaning, for clearness and conciseness of written or oral instruction. If science and knowledge are synonymous terms, if the definition “science is knowledge” is the same with the terms transposed, thus “knowledge is science,” every child and uneducated person who knows that “fire burns,” is a scientist, without, it may be, knowing what fire is, or its causes. Then science would signify no more than knowledge. But all fundamentally distinctive ideas are appropriately expressed by different terms. And it is desirable that the demands of language be recognized, and this practical rule for the use of discriminating words be observed. Synonymous words are properly those which are derived from different languages, and are used for euphony, or variety.

Further, there is a legitimate distinction between common, obvious, or non-scientific knowledge, and scientific knowledge. And this is not a distinction in respect to certainty; for common knowledge is often as certain as scientific knowledge, as in reference to the fall of a body to the earth: while much that is called scientific knowledge is far from being exact in its complete sense, as in respect to the nature of the ultimate cosmic forces, the aurora borealis, and other phenomena. Nor is it a difference simply in degree of knowledge, but a difference also in respect to kind and quality. Thus two persons may observe an eclipse of the sun or moon; one may know only that one body intercepts the light of another body; the other person may know the causes, the sizes, the distances, orbits, periodic times, laws of motion, and many other elements whose knowledge is essential to the determination of the phenomenon. The attainments respectively differ,—the former having only the knowledge of a single fact, the latter the knowledge of the whole system of facts, principles and laws pertaining to the phenomenon; the former possessing ordinary knowledge, the latter scientific knowl-

edge. The distinction is therefore fundamental, and should be recognized as really as other differing facts.

These may be regarded as extreme cases, and it may be said that the point of transition, or the boundary line between the non-scientific and the scientific may not be clearly determined. Be it so; the claims of science require exactness of knowledge to the extent to which the exactness may be obtained by observation or reasoning, and to which the facts themselves fix the standard. And though perfection is the standard and aim, the knowledge of a sufficient number of related facts constituting a systematic knowledge, or knowledge sufficiently "generalized, systematized, and verified," for the comprehension of the relations and laws pertaining to such facts, may be received as evidence of scientific attainment, and capacity for intelligent progress. A man may possess a practical knowledge of carpentry, by which he may perform work, when a frame is "laid out," without the scientific knowledge of the principles, rules or methods by which such work is planned; much less without the higher mathematical and mechanical knowledge of architecture.

Another point of distinction claims attention. The term science is used in both a general, and a special or restricted sense. Either the whole body or aggregate of facts throughout the whole range of phenomena, relations, laws and applications, is referred to comprehensively, as "The classification of all science"; or, a branch or sub-science is referred to specially, as "The Science of Chemistry." Frequently a special-science is recognized by the form of statement implying that to which reference is made, the term science being used by metonymy for a science, or a particular branch of general science, thus: "Science [chemistry] teaches that all masses of matter are made up of elements which had previously been isolated or separate." Or this: "Science [the science of the conservation of the forces] teaches that a certain quantity of heat may be changed into a definite quantity of mechanical work; this quantity of work can also be re-transformed into the same quantity of heat as that from which it originated." It may be added that the term science is sometimes used in an indefinite sense, or without precision, as "a man of science";—one who possesses a wide range of knowledge.

These distinctions between knowledge and science, between non-scientific and scientific knowledge, and between the special and general significations of the term science, being recognized, it remains only to give such forms of definition as shall meet the requirements of the case. The following are believed to be sufficiently precise:

1. Science (special or particular) is a system of phenomena, principles, relations and laws pertaining to a special subject.

2. Science (general or universal) is the aggregate of special sciences.

Many attempts have been made to classify the various sciences. The conception that they are naturally related, intimately, or more remotely, having general or special connections, has led to such arrangement of these in departments and groups as has accorded with the fundamental principles upon which they have been conceived to be allied. And since science consists chiefly of the facts, phenomena, laws, and principles, material or immaterial, which pertain to being, or the forms in which being is known, it is evident that schemes of classification will be adopted according to the systems of philosophy maintained by those who construct them. All classification will hence be observed to conform in general principles of structure to one or another of the three following systems of philosophy with respect to existence, or entities, viz.: Spiritualism, Materialism or Dualism. The first, which includes Idealism, rejects the doctrine of material essence, mind only being held to be fundamental and real—the outer world only phantasmic or apparent, or as held by some, matter

being a mode or manifestation of mind. The second rejects the doctrine of a spiritual entity—the mind or spirit being held to be a phenomenon of matter; force, life and mind being but properties, or special manifestations of matter. Both the above systems are monistic, one substance, or essence, only held to exist. The third maintains the real existence of both matter and spirit in essential connection, yet distinct and unlike, not only in essence, but in their laws of development and modes of action—two related yet diverse processes. This may be termed *Dualistic Realism*, in contradistinction to the *Monistic Realism* predicated of each of the two former systems above mentioned.

But so diverse and even contradictory, in important respects, are many of these schemes of classification, that the question may be asked with pertinence, is any unexceptionable classification possible? Indeed, it has been admitted by men of high scientific standing that the most perfect classification will contain some incongruities and minor imperfections; and that a system substantially correct may, notwithstanding, contain something which is artificial, or merely theoretic. An apparent incongruity may be explained by the fact that several of the sub-sciences bear relations to different and widely separated sciences as to their fundamental characteristics, as will be observed in the scheme of the writer of this article.

A few diverse schemes are here given to illustrate the fact that one's philosophy will determine his principles of classification.

The fundamental principle of Oken, a German philosopher, is, that "Mathematics is the universal science," and holding the transcendental idea that Mathematics is zero, equal to nothing (0), has constructed his scheme to embrace three general classes, viz.: 1. *Mathesis*, the doctrine of the whole; 2. *Ontology*, erroneously defined to be "the doctrine of the *phenomena of matter*," or what seems to be, consistently enough with his doctrine of Idealism; 3. *Biology*, all orders of life and mind. Included in class first he has two groups: 1st. *Pneumatogeny*, the doctrine of immaterial totalities; subjects arranged in the following order: Primary Art, Prim. Consciousness, God, Prim. Rest, Time, Polarity, Motion, Man, Space, Point, Line, Surface, Globe, Rotation. Group 2d, under the term *Hylogeny*, defined to be "the doctrine of material totalities," includes the following: Gravity, Matter, Ether, Heavenly Bodies, Light, Heat and Fire. Included in Ontology he has Rest, Centre, Motion, Line, Planets, Form, Planetary Systems, Comets, Condensation, Simple Matter, Elements, Air, Water, Earth, Mineralogy, Geogony, etc. Other divisions of this anomalous system are here omitted. The author has conceived of a phenomenal process, which is given under the term Ontology, but which, so far as it represents the facts, pertains to cosmogony. It will be observed, moreover, that the place of geogony, to represent a consecutive order, is at the point where the genesis of the earth is given, if it can be found. But this system is based upon the fundamental principle of mathematics, which, according to the author, is zero = 0; for, as it is assumed, "Mathematics is the universal science of forms without substance." Such a system of nothings, consisting of terms, names and propositions, without realities, may well be termed Idealistic Nihilism!

The philosophy of Hegel is founded upon the theory that the essence of the universe is a process of thought from the abstract to the concrete. His classification is based upon Logic, as its fundamental principle, instead of Mathematics, which is Oken's, with which it otherwise well corresponds. A quotation from President Hopkins, that "Classification is a law of *forces*, not a law of logic," may here be given as a sufficient answer to Hegel's principle.

The method of M. Comte, the author of "The Positive Philosophy," gives what he calls "The one rational order," as follows: Mathematics (including mechanics),

celestial and terrestrial physics, chemistry, physiology and social physics. In its general outlines, it is a near approach to the proper order; but, in its special application and interpretation, it is a statement of the philosophy contained in his celebrated work just referred to. In that he gives his theory in the following statements: "Our study of nature is restricted to the analysis of phenomena, in order to discover their laws, and can have nothing to do with their nature, or cause, or the mode of their production." The question is suggested, What is the province of philosophy, if not to explain such nature, cause, and mode of production? He opposes "all inquisition into the essence of things;" rejects all hypotheses of "electric fluids and luminous ethers which are to account for the phenomena of heat, light, electricity, and magnetism." He denies that there can be any such thing as internal observation of the mind, or any knowledge of the causes of phenomena. What does he mean by mind? and how does he know that there are other minds than his own, or what is so called, to study his Positive Philosophy! He defines *law* to be "a constant relation of succession or similitude," and ignores all causes operating in matter, and of course there are no such entities as force, life or mind, human or divine.

In his subdivisions and groups, many incongruities are found, the statement of which must here be omitted. The subject matter of concrete mathematics, which is composed of plane geometry and rational mechanics, he has stated to consist of space, time, motion, and force, whose nature, indeed, may not be inquired into. He undertakes to classify the science in the order of historic development, or progress, which cannot be substantiated. Thus, historically, geometry had advanced to a considerable degree of perfection before the invention of algebra; and chemistry had made considerable progress before geology and mineralogy had become strictly sciences; while many of the facts of zoology had been arranged in systematic order more than two thousand years before the laws or methods of the stratification of the rocks, including immeasurable periods of time, had come to be accepted, as against the almost universally received doctrine of a miraculous creation of "the heavens and the earth," in six literal days about six thousand years ago.

The method of Herbert Spencer, while ostensibly based upon the distinction between the abstract and the concrete sciences, really precedes in development upon the hypothesis of Materialistic Evolution. He classifies the sciences under three tables: 1. *Abstract Science*, which includes mathematics and logic. 2. *Abstract-Concrete Science*, which includes mechanics, meteorology, chemistry, heat, light, electricity, and magnetism. 3. *Concrete Science*, which includes astronomy, astrology and geology. Evolved from the latter are those subjects which are contained in the two following branches; 1. Mineralogy, meteorology, and geology; 2. Biology, out of which evolves morphology, physiology, psychology, and sociology. It will be seen that the distinction between the abstract and the concrete sciences has involved inconsistencies and confusion. While mathematics is appropriately placed first in the order, inasmuch as its principles apply to the measure of content, which belongs to all things susceptible of measurement, especially to the physical, mechanical and chemical departments of science; and also, as numerical mathematics applies to organic being, social statistics, etc., logic pertains to the rational nature and cannot with propriety be placed below both inorganic and organic nature without involving the necessity of separating subjects which are necessarily affiliated, as empirical psychology and rational psychology are. Further, both mathematics and logic are both abstract and concrete, being founded in principles which are applied practically both to forms and things. The term abstract, which means to draw from, or separate, or that which is considered part from its related

subjects, is more appropriately applied to some other sciences than those assumed; thus *Kinematics* is an abstract science, inasmuch as it is "motion considered apart from its causes."

In the second table, the sciences of the laws relative to bodies are given before the recognition of such bodies, as if anticipating them; yet these are given under a two-fold term "abstract concrete," instead of being given as abstract. Thus, in giving the mechanical laws of solids and fluids before the supposed existence of these, is presumption, and we may well ask, how can there be laws of entities which as yet do not exist? for it should be observed, these material entities are expressed in the third table, and as being evolved from terrestrial elements, and included under the term theology. The scheme betrays the design of the classification. It seems evidently devised to exhibit, under the term "concrete," the evolution from matter and motion, of all the "totalities" included in this branch. According to this, matter and motion, in their redistribution, evolve the phenomena of force, life, and mind, while these entities, held as real by a true dualism, are regarded by Mr. Spencer as having no substantive existence, but only modes of motion manifested by matter, the only real existence, according to his philosophy. The author of this scheme proceeds upon the postulate that "The second and third groups supply the subject matter to the first, and the third supplies the subject matter to the second." Why not, then, begin with the subject matter, not simply including material phenomena, but the inherent force, and the laws of manifesting phenomena? He abhors a "serial" order, upon whatever scheme of philosophy, and combats M. Comte on this ground, yet has conveniently adopted it for his main purpose, as betrayed in his third table.

An extended criticism of his system of philosophy, and his classification of the sciences, is not intended in this paper. Such has been given by M. Lettre, Prof. Bain, and others.

Only one other scheme of classification by other persons than the writer of this, will here be given; it is that of Prof. Laurens P. Hickok, D. D., LL. D., who is the author of several profound philosophical works. He gives what he designates a "Rational Method of the Classification of all Science." His method includes two general branches or divisions: 1. Empirical or Inductive Science; 2. Rational or Transcendental Science. These fundamental divisions are clearly defined. The first is limited to *facts* or phenomena; the second to *laws* and *principles*. The first embraces "what is given in experience," using the terms empirical and inductive to include observation and experiment. It is divided into two parts: 1. *Qualities* given in Perception; 2. *Things* given in Reflection; the former grouping external phenomena, as optics, acoustics, etc., the latter grouping things in space and time, including mensuration, substance, cause, counter-cause, chemistry, magnetism, mechanism. The second or rational branch is divided into, 1. Intuitive (all mathematics); 2. Discursive (all philosophy). "Mathematics deals only in forms; philosophy deals only in existences." Discursive science is divided into two parts. 1. *Ontology*, which includes cosmology, psychology, and theology. 2. *Deontology*, defined to be the rule of speculation, includes the canons of taste, (esthetics), politics, ethics, and religion. Cosmology is treated as including not only material nature, but physiology, now classified under biology. According to this scheme, therefore, man's physical nature belongs to cosmology, the term anthropology not being given as it is common with systems of philosophy.

The subdivisions of Dr. Hickok do not appear to be systematically arranged. His special field of thought does not embrace the sciences pertaining to inorganic matter, nor indeed to biology, but lies in the profound depths of transcendental philosophy held to be consistent with christian theism.